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SEVENTH QUARTERLY REPORT  
ON  
**PRODUCTION ENGINEERING MEASURE  
FOR SUBMINIATURE TEMPERATURE-COMPENSATING  
CERAMIC CAPACITORS**

PERIOD: 13 DECEMBER 1962 THROUGH 12 MARCH 1963



CONTRACT NO. DA-36-039-SC-85966  
ORDER NO. 6021-PP-61-81-81

Placed by

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RECEIVED  
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**U. S. ARMY SIGNAL SUPPLY AGENCY**  
PHILADELPHIA, PENNSYLVANIA

**SPRAGUE ELECTRIC COMPANY**  
NO. 072 NORTH ADAMS, MASSACHUSETTS

**PRODUCTION ENGINEERING MEASURE  
FOR SUBMINIATURE TEMPERATURE-COMPENSATING  
CERAMIC CAPACITORS**

**Seventh Quarterly Report**

**Period: 13 December 1962 through 12 March 1963**

**Object of Study: To establish facilities and competence to  
produce subminiature temperature-compensating ceramic capacitors**

**Contract No. DA-36-039-SC-85966  
Order No. 6021-PP-61-81-81**

**Controlling Specifications:**

**Signal Corps Technical Requirements SCL-6415, 6 February 1961  
Signal Corps Technical Requirements SCS-107, 24 February 1961  
Specification MIL-C-20, 11 September 1959**

**Report Prepared by:**

**J. H. Fabricius  
J. H. D. Folster  
T. I. Prokopowicz**

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## SECTION 1

### ABSTRACT

The temperature coefficient of capacitance (TC) requirement for the NP0 capacitors was achieved as a result of work during this period. A recapitulation of areas investigated in the study leading to this attainment is presented herein.

Approval of the Case Size III qualification samples was received, and pilot production on the three formulations of this case size will begin as soon as authorization is received. The status of pilot production for Case Sizes I and II is given in this report.

## SECTION 2

### PURPOSE

The purpose of this contract is as follows:

- (1) To provide the production engineering to establish capability to manufacture subminiature temperature-compensating ceramic capacitors ranging from 22  $\mu\text{f}$ -100 VDC to 6800  $\mu\text{f}$ -100 VDC ratings on a pilot-run basis.
- (2) To design, develop, procure, or manufacture special tooling required for successful pilot-run production.
- (3) To obtain limited production equipment necessary to manufacture 3000 units per eight-hour shift.
- (4) To produce and submit for approval to the U. S. Army Electronics Materiel Agency preproduction samples prior to the initiation of the pilot run.
- (5) To manufacture a pilot run of 3600 subminiature temperature-compensating ceramic capacitors.
- (6) To provide monthly and quarterly progress reports.
- (7) To prepare production engineering measure final reports in accordance with Step II of SCIPPR No. 15, Paragraph 3.8.

## SECTION 3

### NARRATIVE AND DATA

#### 3.1 Selection of Ceramic Materials

Characteristic CF, the TC requirement for NP0 capacitors, was attained for all three case sizes during this period. This attainment followed months of concentrated experimentation, which involved investigation of various approaches, including the following: varying the quantities of ceramic constituents; adding rare earth oxides or other oxides to the ceramics; calcining the formulation before fabrication into ceramic parts; firing the ceramic in a gas kiln; and varying the composition of mixes which contain a smaller particle size than the powder formerly used.

The capability of the Sprague Electric Company to make miniature NP0 capacitors is shown in Table 1. TC data from temperatures of  $-55^{\circ}\text{C}$  and  $+85^{\circ}\text{C}$  only are presented, but experience has revealed that a material within limits at these critical temperatures is always within limits over the rest of the temperature range. The test results in Table 1 are average test results gained from a series of TC runs. All units measured on these runs met Characteristic CF.

Pilot production of Case Sizes I and II of NP0 capacitors, which was held up pending the attainment of Characteristic CF, was begun immediately. Pilot production on all three formulations of Case Size III will begin as soon as authorization is received.

The TC requirements for the N750 and N1400 formulations were previously attained.

#### 3.2 Development of Spraying Capability

The current spraying capability is as follows:

- (1) Spraying slips of the NP0 and N750 formulations made with the preferred binder system are satisfactory.



TABLE 1

One Hundred Kilocycles/Second Capacitance Change with Temperature  
From Capacitance at 25°C for NP0 Capacitors in Case Sizes I, II, and III  
Monolythic® Form and Characteristic CF  
(Parts per Million)

<u>Case Size</u>	<u>Group Designation</u>	<u>Capacitance (<math>\mu</math>f)</u>	<u>Limits</u>	<u>-55°C</u>	<u>+85°C</u>
		Characteristic CF	Max.	2800	900
			Min.	-900	-900
I	E	25		30	-30
II	5*	330		456	-558
III	4	1500		136	-384
III	2	1500		-160	- 84
III	1	1500		-240	- 6

\*This TC run was at 1 Mc/sec.

- (2) Spraying slips of the N1400 formulation made with the alternate binder system are satisfactory.

### 3.3 Development of Dip Method

Dipping slips for the three formulations are satisfactory.

### 3.4 Qualification Test Samples

#### 3.4.1 Case Size II

Qualification test results from Test Groups I-IV of the Case Size III units (Contract Item 1-3-9) were reported in the Sixth Quarterly Report. Results from the final group are given below:

#### Test Group V

All testing is completed. All units passed.

Test reports and samples were submitted to the U. S. Army Signal Materiel Support Agency February 19, 1963.

### 3.5 Approval of Case Size III Qualification Samples

Technical Action Request FEB-4 deeming acceptable the 128 Case Size III units which underwent qualification testing (Contract Item 1-3-9) was received March 14, 1963.

### 3.6 Pilot Production

Pilot production of Case Size I of Formulations N750 and N1400 (Contract Items 1-3-2 and 1-3-3, respectively) and of Case Size II of Formulations N750 and N1400 (Contract Items 1-3-5 and 1-3-6, respectively) is now completed. Pilot production of Case Size I and Case Size II of the NP0 formulation (Contract Items 1-3-1 and 1-3-4, respectively) is under way. Pilot production of Case Size III of all three formulations (Contract Items 1-3-7, 1-3-8, and 1-3-9) will begin as soon as authorization is received.

## SECTION 4

### CONCLUSIONS

- (1) Characteristic CF, the temperature coefficient of capacitance requirement of NP0 capacitors, has been attained for all three case sizes.
- (2) Test results from qualification testing of Group V of the Case Size III capacitors of the N1400 formulation are satisfactory.
- (3) Pilot production of Case Size I of Formulations N750 and N1400 (Contract Items 1-3-2 and 1-3-3, respectively) and of Case Size II of Formulations N750 and N1400 (Contract Items 1-3-5 and 1-3-6, respectively) is now completed.
- (4) Pilot production of Case Size I and Case Size II of the NP0 formulation (Contract Items 1-3-1 and 1-3-4, respectively) is under way.
- (5) Pilot production on Case Size III of all three formulations (Contract Items 1-3-7, 1-3-8, and 1-3-9) will begin as soon as authorization is received.
- (6) The estimated percentages of the overall progress on the major elements of the program are as follows:

<u>Factor</u>	<u>Relative Weight</u>	<u>% Completion</u>	<u>Percentage</u>
1. Production Design Engineering	<u>25</u>	98.0	24.5
2. Engineering and Design of Special Tooling and Refining Equipment	<u>15</u>	98.0	14.7
3. Preproduction Sample Approval	<u>15</u>	95.0	14.2

<u>Factor</u>	<u>Relative Weight</u>	<u>% Completion</u>	<u>Percentage</u>
4. Pilot Run	<u>25</u>	51.5	12.9
5. Monthly & Quarterly Reports	<u>10</u>	81.3	8.1
6. Final Report, Step II Study and Inspection Test Report	<u>10</u>	0.0	0.0
TOTALS	100		74.4

**SECTION 5**  
**PROGRAM FOR NEXT QUARTER**

- (1) Pilot production will continue.
- (2) The effort toward producing satisfactory spraying slips of the N1400 formulation and the preferred binder will continue.

## SECTION 6

### PUBLICATIONS AND REPORTS

The following reports were submitted to the U. S. Army Electronics Materiel Agency during the quarter:

- (1) The sixth quarterly report, covering the period 13 September 1962 through 12 December 1962, was submitted for U. S. Army Electronics Materiel Agency approval. This approval was received, and the report was distributed per USAEMA instructions.
- (2) Monthly reports for December, 1962, comprising narrative reports, progress reports on SA-SC Forms 109-1 and 109-2, and progress percentage calculations.
- (3) Monthly reports for January, 1963, comprising the same.
- (4) Monthly reports for February, 1963, comprising the same.

SECTION 7  
IDENTIFICATION OF PERSONNEL

<u>Personnel</u>	<u>Hours</u>
W. Baker	1.5
D. Bellows	12.0
J. Dziok	3.0
W. Estes	122.5
J. Fabricius	19.0
R. Fisher	15.0
W. Hatch	67.5
R. Immediato	31.3
T. Jammallo	107.0
E. Jamros	1.5
E. Jones	8.5
L. Lamore	5.5
J. Ledoux	6.3
R. Lee	5.5
L. Lemoine	2.0
P. Moriarty	116.0
J. Newman	32.0
G. Olsen	3.0
T. Prokopowicz	15.5
H. Raithel	5.0
D. Reid	16.0
R. Trottier	12.0
K. Whitney	17.0
J. Willey	72.0
M. Zedalis	1.0
Total	697.6

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